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CHOICE OF NEST BOXES BY COMMON GOLDENEYES IN ONTARIO

Harry G. Lumsden, R. E. Page and M. Gauthier

Nest boxes were hung on trees for Common Goldeneyes (*Bucephala clangula*) in Scandinavia over 240 years ago (Linnaeus *in* Phillips 1925, Lloyd 1854) to provide a ready source of eggs for human consumption. The use of boxes to increase stocks is more recent and has been practiced in Europe as well as North America.

Few data exist in North America on the size of natural cavities chosen by goldeneyes. Sixteen cavities found in New Brunswick (Prince 1968) had an average inside diameter of 20.6 ± 4.1 cm, a depth of 46.2 ± 19.6 cm, and the average size of the entrance hole was 22.4 ± 16.3 cm long × 11.4 ± 3.6 cm wide. Ten of these 16 cavities were open at the top like a chimney. Siren (1951) tested hollow pine logs in Finland with a variety of dimensions and recommended specific measurements. Palmer (1976) also made recommendations. These are summarized in Table 1 with the measurements of nest boxes used by 5 other investigators in their studies of nesting goldeneyes. The purpose of this paper is to describe the results of selection experiments in which goldeneyes were presented with boxes with a variety of features.

MATERIALS AND METHODS

The work was started in 1974 and continues on 3 study areas in Ontario: Elk Lake (47°44′N, 80°20′W); the Englehart River including Robillard, Kinogami and Kushog lakes, known collectively as Long Lake, near the village of Charlton (47°48′N, 79°59′W); and on the Mattagami and Muskego rivers west and south of Smooth Rock Falls (49°17′N, 81°38′W).

We used nest boxes made from 1.27 cm sheeting grade plywood, with a relatively rough surface. The internal measurements were 21 × 24 cm × 45 cm high at the back, with a roof that sloped downward to 42.5 cm at the front. The bottom of the entrance hole was varied in 1 experiment, but in others was 33 cm from the floor; it was cut into a removable inspection plate held in place on the front of the box by 2 turn buttons. The outside of the boxes was stained and all exposed plywood edges and knots were treated with clear marine varnish. Boxes were mounted in sets of 2 or 3, on 2 horizontal supports nailed about 3 m from the ground to trees on the lake shore or river bank. Where 3 boxes were used the center one was aligned with the tree trunk; branches and shrubs were trimmed so that entrances were unobstructed and visible from the water. The boxes were visited at intervals averaging about 4 days (1–10 days), beginning as soon as ice melt permitted in late April or early May and continuing well into June.

The first test compared the response of goldeneyes on Elk Lake to dark vs light interiors of the boxes. There were 73–75 sets available annually for 6 years. We hypothesized that a searching female would respond to the dark entrance of a cavity and that, when given a choice, the bird would choose the hole that appeared darkest. Two boxes were mounted side by side, 60 cm apart, one of each pair was painted black inside, the other was clean, unstained plywood. All exteriors were stained light brown. Entrance holes were oval, measuring 10.5 cm wide × 8 cm high.

For the second selection test, compass bearings taken at right angles to the horizontal axis of the sets of boxes on Elk and Long lakes were recorded and grouped for analysis. The Elk Lake boxes and 100–105 sets on Long Lake were available annually for 6 years for this analysis.

The third test compared the choice by goldeneyes on Long Lake and the Mattagami and Muskego rivers among sets of 3 boxes with large (13 cm wide × 10 cm high), medium (10.5 × 8 cm) or small (7.5 × 6 cm) oval entrance holes. Box interiors were painted black. The smaller Hooded Merganser (*Mergus cucullatus*) nests in this area as well as the goldeneye and may compete for nesting cavities. It was hypothesized that the 2 species would divide the available cavities on the basis of size of entrance hole. The smallest entrances were large enough to admit Hooded Mergansers, but too small for goldeneyes. The positions of the 3 types of boxes in each set, and the order of placement of the sets around the shore, were systematically varied according to a Latin Square. Sets were spaced 0.6–1.2 km apart. The number of sets of boxes on the Mattagami and Muskego rivers varied from 64–46 because many box trees were cut by beaver (*Castor canadensis*) or were knocked down by ice at breakup. For 2 years, 103 and 105 sets of boxes on Long Lake were used in this test.

The variation in the depth of boxes (22–41 cm) used in previous studies (Table 1) and the frequency with which goldeneyes used relatively shallow, rotted-out Common Flicker (*Colaptes auratus*) holes in Ontario, suggested that material can be saved if goldeneyes accepted shallow boxes as readily as deep ones.

The fourth test compared choices by goldeneyes of shallow boxes, 18 cm from the floor to the bottom of the entrance hole; medium-depth boxes 25.5 cm deep and deep boxes, 33 cm deep. All were fitted with large entrance holes, 13 × 10 cm. One hundred and 101 sets of boxes on Long Lake were used for this test in 1975 and 1976. Their depth was adjusted with the use of wooden inserts that provided false bottoms.

The fifth test was the influence of the tree species on box selection. We selected trees for boxes primarily for their proximity to the shore and their relative immunity from cutting by beaver. We therefore favored black ash (*Fraxinus nigra*) and balsam poplar (*Populus balsamifera*), over trembling aspen (*P. tremuloides*) and white birch (*Betula papyrifera*). Conifers were seldom chosen since they were small or sparsely distributed near water, or were situated in dense cover. Other factors affecting our selection of trees for boxes included spacing along the shore, access by boat and size and visibility from open water. A total of 174 sets of boxes over a 5 year period were used in this test.

Choice by a goldeneye was defined as the laying of 1 or more eggs in a box, even though the female may subsequently desert. In all tests the results involve multiple use of some of the boxes in different years, in some cases by the same female. To ensure independence of data for statistical analysis, boxes were scored only as used or not used, and the number of uses per box was ignored.

RESULTS

Goldeneyes generally selected black instead of unstained interiors (Table 2), based on data excluding multiple use of the same box. Including multiple uses, there were 39 choices of black and 13 of unstained boxes.

There was no evidence for selection of nest boxes facing 8 sectors of the compass (Table 3). Nor was there selection for southerly (90° through S to 270°), or northerly facing boxes ($\chi^2 = 0.061$, df = 1, $P > 0.05$).

TABLE 1

SUMMARY OF DIMENSIONS AND MATERIALS USED FOR GOLDENEYE NEST BOXES

Source	Cavity		Entrance hole		Height of box above ground	Construction material
	Floor area	Total depth	Size	Height above floor		
Siren (1951) recommendation	19–22 cm diameter	—	10–11.5 cm	35 cm	3–4 m	hollow pine logs
Palmer (1976) recommendation	23 × 23 cm	60 cm	10.5 × 8 cm	—	—	—
Gibbs (1961)	25.4 × 25.4 cm	61 cm	8.9 cm diameter	—	—	rough lumber
Johnson (1967)	30.5 × 30.5 cm	61 cm	12.7 × 10.2 cm or 11.4 × 8.9 cm ellipse	—	—	wood
Johnson (1967)	30.5 cm diameter	76.2 cm	—	—	—	metal drums
Rever and Miller (1973)	15.2 × 19.0 cm	61 cm	12.7 cm diameter	39.4 cm	2.4–3.7 m	spruce boards
Corbould (1969)	17.8 × 22.9 cm	43.2 cm	11.4 × 8.9 cm	22.9 cm	—	lumber
Irving Benson (pers. comm.)	21.6 cm diameter	—	11.4 × 12.7 cm	21.6 cm	—	hollow cedar logs

TABLE 2

CHOICE OF NEST BOXES BY GOLDENEYES IN SETS WITH 1 BLACK AND 1 UNSTAINED INTERIOR OF WHICH 1 OR BOTH BOXES IN EACH SET WERE USED

	Number of boxes	
	Used	Unused
Black interior	23[a]	2
Unstained interior	7	18
Cochrane Q = 36.15, df = 1, $P < 0.001$		

[a] Both boxes in some sets were used simultaneously by different females.

Both species of ducks showed a strong preference for large entrance holes. Goldeneyes used boxes with large holes in 32 cases, medium in 3 and were unable to squeeze through the small entrances. Hooded Mergansers chose the large in 9 cases, the medium in 4, and the small entrances in none. Table 4 summarizes the data after multiple use of single boxes has been eliminated.

In all cases goldeneyes selected deep boxes ahead of the medium and shallow. In total, 12 different boxes were used 16 times, but no medium or shallow boxes were used (Cochrane Q test = 24, df = 2, $P < 0.001$). Alignment of a box with the trunk of a tree in the center of a set of 3 did not influence selection on Long Lake and the Mattagami and Muskego rivers. Goldeneyes used the right, center and left boxes 17 times each. In the fifth test there is no evidence that the species of tree on which the set of boxes was mounted influenced the goldeneyes in their choice (Table 5).

DISCUSSION

Our data demonstrate that the colors of the interiors of nest boxes can influence the degree of use by target species. Such preferences have been tested experimentally in only a few species. Blagosklonov (1970) showed

TABLE 3

ACCEPTANCE OF NEST BOXES BY GOLDENEYES FACING 8 SECTORS OF THE COMPASS ON ELK AND LONG LAKES

	N-NE	NE-E	E-SE	SE-S	S-SW	SW-W	W-NW	NW-N
Available	17	32	13	7	18	50	26	11
Used	6	12	6	2	5	19	11	6

$\chi^2 = 1.28$, df = 7, $P > 0.05$, using the correction for continuity of Siegel (1956)

TABLE 4

CHOICE BY GOLDENEYES AND HOODED MERGANSERS OF BOXES WITH LARGE, MEDIUM AND SMALL ENTRANCE HOLES

Species	Entrance size	Number used	Number unused
Goldeneyes			
	large	28[a]	1
	medium	3	26
Cochrane Q = 23.14, df = 1, $P < 0.001$			
Hooded Mergansers			
	large	9[a]	3
	medium	4	8
	small	0	12
Cochrane Q = 10.16, df = 2, $P < 0.01$			

[a] Different females simultaneously used 2 boxes within a set.

that the Pied Flycatcher (*Muscicapa hypoleuca*), in the Moscow region, chose boxes with white or clean interiors more frequently than those with black or dirty interiors. Pitts (1977) also demonstrated that Eastern Bluebirds (*Sialia sialis*) and House Sparrows (*Passer domesticus*) in Tennessee selected boxes with white interiors more frequently than those with black. However, Lumsden (1976) reported that Starlings (*Sturnus vulgaris*) in Ontario, as with the goldeneyes in this study, chose black interiors in preference to unstained plywood interiors.

Light within the box was probably one of the influences affecting these choices. Blagosklonov (1970) reported that reflected light levels in boxes

TABLE 5

SPECIES OF TREE ON WHICH SETS OF BOXES WERE MOUNTED AND THEIR USE BY NESTING GOLDENEYES

Species of tree	Number available	Number used	Percent used
Trembling aspen	13	5	38
Balsam poplar	76	23	30
White birch	28	8	29
Black ash	51	10	20
Conifer	7	1	14
Totals	175	47	—
$\chi^2 = 1.94$, df = 4, $P > 0.05$			

with dirty interiors were much lower than in clean boxes. He concluded that the size of the entrance hole, the depth of the cavity and other factors are of secondary importance and only influence acceptance of a cavity to the extent that they affect light. From this it would appear that some species prefer a higher reflected light level, while others, such as the Starling, desire a darker cavity.

Most cavity nesting birds depend greatly on holes excavated by woodpeckers. A number of studies have shown that woodpeckers often cut the entrance to their cavities facing in a specific direction. Conner (1975) briefly reviewed this phenomenon and showed that different species of woodpeckers respectively orient the entrance to their nests to the southwest, to the southeast and even to the northeast.

The Bufflehead (*Bucephala albeola*) typically uses flicker holes as nest-sites. McLaren (1958), using largely Erskine's data, studied the use by 5 species, including Buffleheads, of flicker holes in British Columbia. These records, re-analyzed here, indicated that flicker nest holes in use by all species faced in a southerly (SE–SW) direction more frequently than to the north (NW–NE) ($Z = 4.37$, $P < 0.001$, binomial test for large samples). However, the Bufflehead's choice was not significantly in favor of southerly facing entrances ($Z = 0.788$, $P > 0.05$). Buffleheads did, however, have a tendency to choose sites which offered a relatively unobstructed flight path to the entrance hole (Erskine 1972).

The direction of rain-winds or the warming effect of sunshine may affect the choice of cavities with specific compass orientation by hole nesting species and also of boxes by goldeneyes. Dement'ev and Gladkov (1967) report that a major cause of nest desertion by goldeneyes at the Rybinsk reservoir in the unusually wet summer of 1951 was soaking of nests by rain. Since nest entrances facing the prevailing rain-winds are more likely to become saturated than those facing away, birds may select against boxes facing rain-winds.

The Atmospheric Environment Service has supplied us with weather records for Earlton airport which lies about 25 km east of the center of the Elk Lake/Long Lake study areas. Hourly records of wind direction when rain was falling were compiled for 1957–1976 for May and June, the months of most laying and almost all incubation. Only winds of more than 5 mph were included to calculate the percent frequency of rain-winds blowing from 16 points of the compass. The highest frequency of rain-winds (32%) were from NW, NNW and N. From the choices of box orientation (Table 3) there is no evidence that goldeneyes were influenced by the direction of rain-winds.

If sunshine warming goldeneye boxes with a southerly exposure (90° through south to 270°) had any influence, one would expect that northerly facing boxes (270° through north to 90°) would differ in their rate of use from those with a southerly orientation. Since this choice pattern did not prevail, we conclude that goldeneyes were not influenced by this factor. It is, however, possible that either conflicting choice patterns obscured any specific directional orientation that they might have had, or that relatively large birds like the goldeneye and Bufflehead are not influenced to the same extent by these factors as smaller cavity nesting woodpeckers and passerines.

The choice of large entrance holes by goldeneyes was somewhat unexpected. Most of the papers cited in Table 1 recommended or used smaller holes than the large entrances chosen by goldeneyes in this study. However, Prince (1968) showed that the entrances to natural cavities used by goldeneyes averaged 22.4 × 11.4 cm. There were 2 occasions in our study when the inspection plate containing the entrance hole fell off the box, providing an entrance 21.5 × 13.5 cm. This extra large entrance was chosen in both cases in preference to a 10.5 × 8 cm entrance. Bent (1925) mentioned hearing much scrambling and scratching as an incubating goldeneye climbed to a small opening of a natural cavity. Incubating females on our study areas sometimes tried to flush as the field crew grounded their boat on the shore beneath the box tree. Frequently the female would make more than 1 attempt to jump to the entrance, falling back onto the eggs with much flapping and scrambling. Other females seemed to jump to the entrance without difficulty. A large entrance hole probably facilitates escape from a cavity at the approach of a predator.

The Hooded Merganser accepted large entrances 9 times, medium entrances 4 times, but also rejected the small entrances, although they could have had exclusive use of them. This suggested that the goldeneye and Hooded Merganser do not divide the cavity niche in the Long Lake area on the basis of the size of the entrance hole.

Creation of new nest holes each year by the Great Black Woodpecker (*Dryocopus martius*) (Siren 1951) resulted in numerous old cavities being available as goldeneye nest-sites in Finland. In New Brunswick, Prince (1968) reported that only 3 of 46 cavities that he studied were made by Pileated Woodpeckers (*D. pileatus*), the rest being formed as a result of tree rot where limbs had broken off. In addition, most of the cavities were in hardwoods such as silver maple (*Acer saccharinum*), some were in American elm (*Ulmus americana*) and 1 in a butternut (*Juglans cinerea*). Forty-three (93%) were in living trees that could be expected to stand for many years.

Most of the natural cavities available close to the water in the Elk Lake area were in trees with relatively soft wood, such as trembling aspen, balsam poplar, white cedar (*Thuja occidentalis*) and white spruce (*Picea* *glauca*), or in harder black ash and white birch. The rectangular entrances of the Pileated Woodpecker were evident in very few cavities. Most holes resulted from initial excavation by flickers and subsequent enlargement by rot. Measurements of such holes are lacking since most were in dead and rotting trees unsafe for climbing. Erskine (1978) estimated that about one-half of all nests in trembling aspen in the dry climate of British Columbia were still useable after 7 years and one-third after 15 years. In the relatively damp climate of northern Ontario dead aspens and birches do not stand for many years. It is likely that flicker cavities do not rot to a great depth before the tree falls. Natural cavities available to goldeneyes likely would be serviceable for relatively few years and would tend to be shallower than those in living hardwoods or those made by Pileated Woodpeckers.

The goldeneyes on Long Lake did not indicate adaptation to shallow cavities in their choices, however. Although Prince (1968) showed that the range of depth of natural cavities chosen by goldeneyes ranged from 15–76 cm (average 46.2 cm), we found that goldeneyes at Long Lake favored boxes 33 cm deep. Perhaps still deeper boxes would be preferred.

SUMMARY

Choices among boxes offering a variety of features were recorded for goldeneyes in a series of controlled experiments in northern Ontario. Goldeneyes preferred boxes with black interiors, large entrance holes (13 × 10 cm) and a depth of at least 33 cm. Compass orientation, alignment with a tree trunk and species of tree on which the boxes were situated were not factors in selection.

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COLOR PLATE

The color plate Frontispiece of the Guayaquil Woodpecker (*Campohilus* [*Phloeceastes*] *gayaquilensis*) has been made possible by an endowment established by Dr. George M. Sutton.